A STUDY OF THE VARIOUS APPROACHES FOR THORACOTOMY IN CANINES

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INTRODUCTION

Thoracotomy may be defined as the surgical incision of the thoracic wall for visual inspection, surgical exploration and operative procedures on intra-thoracic structures.

Prior to 1940, surgical intervention of the canine thoracic cavity was rarely considered as a means of therapy in Veterinary Medicine except by a very limited number of men in the field of canine surgery. Pugh's operation which consisted of a fifth or sixth rib resection and drainage of the pericardial sac was occasionally utilized by large animal surgeons as a last resort treatment of traumatic pericarditis.

Text books on Veterinary Surgery printed before 1930, described only Paracentesis thoracis, under the heading, "Surgery of the Thorax". "Veterinary Surgical Operations" written by Bemis and published in 1932, described such surgical conditions as traumatic pericarditis, costal sinus and fistula, and sternal fistula. Markowitz (1937) described the entry into and closure of the canine thoracic cavity. Canine surgery (1952) written by 38 American authors was the first text book in English to give an adequate description of thoracotomy in small animals.

Recognized indications for thoracotomy are pneumonectomy or lobectomy, extirpation of tumors or cysts in the mediastinal lymph glands, ventriculotomy, arteriotomy, patent ductus arteriosus, cardioplasty, persistent right aortic arch, thoracic esophagotomy, ligation of the thoracic duct and diaphragmatic hernia.

Pneumonectomy or lobectomy may be necessary when the damage as a result of neoplasm or infection becomes so great that the affected portion of the lung is no longer capable of performing its normal respiratory function.

Occasionally, tuberculosis (Fielder and Brody, 1955) and primary tumors (Mather and Low, 1953) such as fibrosarcoma, chondrosarcoma, epidermoid carcinoma, osteosarcoma, mixed tumors or secondary metastatic tumors of the lungs (Leighton and Stoyak, 1953), may produce hypertrophic osteo-arthropathy. Hypertrophic osteo-arthropathy is characterized by the proliferation of the periosteum of the long bones of the extremities which is secondary to lesions in the lungs. Radiographic examination of the lungs may suggest the possibility of either pneumonectomy or lobectomy as a therapeutic measure.

Surgery involving the heart presents several inherent difficulties that must be overcome to be successful. The principal difficulty of cardiac surgery is that the circulation of blood cannot be stopped for more than a few minutes without producing damage to the nervous system due to anoxia. However, any surgical procedure on the heart is possible if the fundamental function of the heart is not severely reduced. Essex (1950) was successful in the surgical removal of canine heart worms by ventriculotomy. Roenigk (1958) removed heartworms by pulmonary arteriotomy. Dann and Blansfield (1959) successfully performed surgical repair of a patent ductus arteriosus in a puppy. The operation consisted of locating the ductus arteriosus between the aorta and pulmonary artery, dissecting carefully the adventitia of the aorta and pulmonary artery, clamping and dividing the ductus and suturing the divided ends.

A persistent right aortic arch in the dog may cause esophageal obstruction. In these cases structures such as ductus arteriosus or the ligamentum arteriosum and the left aortic arch in conjunction with the persistent right aortic arch form a "vascular ring" which embraces the trachea and esophagus and in so doing give rise to characteristic symptoms.

Congdon (1922) has very aptly described the formation of the aortic arch and its possible embryonic variations. The obstruction soon leads to dilatation and pouching of the esophagus above the site of the constriction. The condition becomes progressively more severe and death from inanition will occur. In severe dilatation a food filled pouch may be felt anterior to the thoracic inlet.

Surgical intervention is the only treatment. In the canine, the right aortic arch and ligamemtum arteriosum type of ring have been described and repaired surgically by Detweiler and Allam (1953) and Coward (1954). Lawson et al. (1957) performed successful surgery on a double aortic arch. In some cases these developmental anomalies do not produce symptoms but are discovered on autopsy.

Intrathoracic esophagotomy has been performed for the removal of spirocercal nests or tumors. The condition is diagnosed by the microscopic examination of the feces for ova and radiographic examination of the esophagus with or without the aid of contrast media. Surgical treatment consists of thoracotomy and removal of the lesion from the esophagus. The mucous membrane of the esophagus is left intact and the esophageal defect produced by surgery is repaired by suturing the muscular wall of the esophagus (Menon, 1953).

Foreign bodies of the esophagus are fairly common in the canine. The term foreign body designates any solid substance retained in the esophagus. The size and shape of the foreign body will determine the extent of the obstruction produced. The common sites of obstruction are at the thoracic inlet, immediately above or posterior to the heart, and anterior to the cardia. Suspected cases are subjected to endoscopy and radiography for

diagnosis. Severe obstructions may require esophagotomy (Knight, 1951).

Achalasia or cardiospasm designates any condition in which contraction of the smooth muscle fibers of the esophagus produces a mechanical obstruction to the passage of food from the esophagus to the stomach. The accumulated food and water in the esophagus produces a gradual dilatation of the lumen due to weakening of the smooth muscles. As the condition progresses the act of vomiting takes place effortlessly and for the most part unexpectedly. Treatment consists of thoracotomy to expose the terminal portion of the esophagus. The wall of the esophagus, the esophageal hiatus, and the cardia are incised longitudinally and sutured to the diaphragmatic wound. This will prevent cicatricial contraction and the formation of a stenosis as healing occurs. The wound in the diaphragm is closed by interrupted sutures and the esophagus returned to its normal position (Hofmeyer, 1958).

A diaphragmatic hernia is formed when the abdominal viscera enters the thorax through an opening in the diaphragm. It may be congenital or acquired. Accidental rupture usually occurs from abdominal crushing as a result of an accident such as being run over by a car, falling from some height or from a severe blow. Radiography is essential for an early diagnosis. The administration of a radiopague substance is of considerable value in the radiographic diagnosis. Treatment consists of the surgical repair of the tear. The surgical approach may be either thoracic or abdominal. Schneider (1934) utilized the abdominal approach. Secord (1942) described the thoracic approach.

Traumatic chylothorax in small animals have been reported and successfully treated by Patterson and Munson (1958). Effusion of chyle into the

pleural cavity is due to rupture of the thoracic duct resulting from either direct or indirect trauma. Treatment consists of thoracotomy, locating the thoracic duct between the aorta and vena cava, and ligating it at the level of the tenth thoracic vertebra.

Despite this array of excellent works, there exists a general apathy towards thoracotomy in present day Veterinary Medicine. This may be due partly to the fact that some text-books preface the description of thoracic surgical procedures with the statement, "Invasion of the thoracic cavity for operations on intrathoracic structures poses special problems. Most important of these are anesthesia and maintenance of respiration. Because the canine mediastinum is flimsy, opening of the pleural sac of a dog results in collapse of both lungs. Consequently operations which necessitate opening of the thorax can be performed only with the aid of positive pressure ventilation."

Other factors contributing to general apathy toward thoracotomy may be the cost of equipment for positive pressure ventilation. The need of an assistant and the seemingly relatively low incidence of conditions requiring thoracic surgery may also be important.

The standard method for thoracotomy has been the lateral approach ever since its inception by Secord (1942). This method may be performed either by an intercostal incision or by rib resection. The rib resection or the inter-costal incision is performed on or between the fourth, fifth, sixth and seventh ribs respectively. The structures in the anterior mediastinum are difficult to reach through these sites and the space afforded is generally insufficient for bimanual exploration and visual inspection. Artificial lighting of the thorax also is hampered.

With these factors in mind, this study was undertaken to explore additional sites for thoracotomy so as to improve the accessibility and visibility of the vital structures, facilitate bimanual exploration, illuminate the interior properly and as far as possible simplify the technique.

While not directly associated with the primary purpose of the study, various means of maintaining respiration were utilized in an attempt to evaluate their effectiveness.

REVIEW OF LITERATURE

Arturo Castiglioni (1941) suggested that the delayed development of thoracic surgery was primarily due to difficulties and dangers inherent to the collapse of the lung as soon as negative pressure within the thorax was equalized by the opening of the thoracic cage. Sauerbruch described a cumbersome apparatus which was partially successful in overcoming the danger of lung collapse. In 1909 Meltzer and Huer demonstrated that respiration could be indefinitely maintained by air introduced intratracheally under positive pressure.

Until 1930 thoracic surgery was an unknown and unexplored field in Veterinary Medicine. Adams and Livingstone (1932) described experimental lobectomy and pneumonectomy in dogs. For lobectomy the incision was made through the skin over the sixth rib and, after resecting the rib, entry was made into the pleural cavity by incising the rib bed. Pneumonectomy was carried out by incising the skin over the fifth rib and following subperiosteal rib resection, entry was gained into the pleural cavity through the periosteal rib-bed. As the diagnosis of diaphragmatic hernia became more common, the need for thoracotomy became more evident. Schneider (1934)

utilized the abdominal approach for repair of the diaphragmatic hernia. Markowitz described the technique of thoracotomy utilizing an intercostal incision in 1937. Five years later, Secord (1942) described the successful repair of diaphragmatic hernias, through an intercostal incision between the sixth or seventh intercostal spaces. Garlick (1945) advocated an abdominal incision extending posteriorly from the xiphoid cartilage. Blakely and Munson (1945) suggested that a minimum of four men were required to repair a diaphragmatic hernia through the midline abdominal incision.

Further advance was made in thoracic surgery when Essex and Schlotthauer (1949) incised the fourth or fifth intercostal space on the right side of the thorax and successfully removed adult filaria from the canine heart. In 1950, Essex perfected his technique of arteriotomy and suggested entering the thorax through the fourth intercostal space on the left side.

Knight (1951) successfully removed a foreign body by means of a "transthoracic" esophagotomy. The approach to the thorax was through the intercostal space. Menon (1953) performed a seventh rib resection and an intercostal incision at the seventh intercostal space for the removal of spirocercal nests. Markowitz (1937) described a technique for surgery on the thoracic portion of the esophagus. He suggested the incision be made in the seventh intercostal space extending from the spinal column to the sternum. Hofmeyer (1956) entered the thorax through the eighth intercostal space and successfully performed cardioplasty for achalasia in the dog. Lumb and Carlson (1956) performed pulmonary lobectomy for a malignant mixed cell tumor with hypertrophic osteoarthropathy. Subperiosteal resection of the sixth left rib combined with transection of the seventh gave access to the thoracic cavity. Brody and Wind reported a successful lobectomy for pulmonary osteoarthropathy in 1957. Rex (1959) performed thoracotomy through

the fourth intercostal space and had to remove portions of the fifth, sixth, seventh and eighth ribs along with the lobe of a lung in a case of chronic pulmonary osteoarthropathy. Butler (1957) described the transthoracic approach for diaphragmatic hernia in cats by incising the seventh intercostal spaces of both sides and a transverse cutting of the sternum. Spellman (1952) entered the thoracic cavity of a cat through the fifth intercostal space on the left side for correcting a diaphragmatic hernia.

Detweiler and Allam (1955) and Coward (1957) operated on two cases of persistent right aortic arch and ligamentum arteriosum causing esophageal obstruction. Coward entered the thorax through the fifth intercostal space on the left side. Lawson et al. (1957) operated on a double aortic arch. The entry into the thorax was through the bed of the fourth rib on the left side. Dann and Blansfield (1959) repaired a patent ductus arteriosus in a puppy. The thorax was invaded through the fourth left intercostal space which was also the site utilized by Roenigk (1958) for surgery of the heart.

Patterson and Munson (1958) described the syndrome of traumatic chylothorax in small animals and the procedure for ligation of the thoracic duct. The thorax was entered through the eighth intercostal space on the right side. In cats the left side was preferred.

The lateral approach thus became the accepted procedure for thoracotomy in dog and cat. It may be accomplished by either an intercostal incision or a rib resection. Secord (1942) was the first exponent of the intercostal method. The incision was made through the skin, cutaneous trunci and fascia in the mid-intercostal space. This prevents damage to the intercostal vessels which lie close to the posterior edge of the ribs. The latissimus dorsi muscle is severed and the fibers of the serratus ventralis separated

to expose the intercostal muscles. Other muscles cut or separated were the longissimus dorsi and the external abdominal oblique. This however, depends on the length of the incision. Both intercostal muscles were then incised to expose the pleural cavity. When the primary purpose of surgery had been accomplished, the adjacent ribs were approximated with strong retention sutures. This was followed by suturing the pleura and intercostal muscles. The fibers of the external abdominal oblique and serratus ventralis were approximated and the latissimus dorsi was sutured. Suturing of the skin completed the closure.

In resection of the rib, the skin incision was made over the selected rib. After incising the cutaneous trunci muscle, fascia, the latissimus dorsi, serratus ventralis, longissimus dorsi and external abdominal oblique muscles, the periosteum was carefully separated from the rib. The rib was removed and entrance into the thorax was made through the periosteal rib bed. After the necessary intra-thoracic procedures are completed, the periosteum was sutured. This was followed by approximating the fibers of the external oblique muscle and the serratus ventralis muscle. Completion of the thoracotomy consisted of suturing the skin. The principal advantage of the rib resection was the ease of suturing the pleura and periosteum and the improved accessability to the thoracic viscera.

For the performance of thoracotomy, positive pressure ventilation of the lungs was required. Schneider (1934) maintained artificial respiration by means of the automobile pump. This was a simple and efficient method entailing no expensive equipment. When a hand or leg pump was used, it was connected to a rubber colon tube of a size suitable for the patient by a valve stem from which the valve had been removed. An elliptical opening

small enough to be covered with the thumb was cut in the top end of the tube. With the tube in the trachea and fixed firmly to the upper jaw, the pump operator placed his thumb over the hole in the colon tube and pushed down on the pump handle thereby inflating the lungs. The thumb was immediately relaxed and the expired air passed out through the opening. The trachea was examined for air escaping around it.

Secord (1938) demonstrated artificial respiration for chest surgery at the Annual Meeting of the American Animal Hospital Association. Schnelle (1939) suggested the use of the milk fever pump and bicycle pump in place of the motor car pump.

Garlick (1945) performed his operation without the aid of a forced air respirator. When the lungs collapsed and respiration ceased manual pressure was quickly applied to the thorax, forcing the air out of the pleural cavity. Vacuum was maintained by covering the rent in the diaphragm with two fingers, hemostats were quickly applied to the edges of the tear and the diaphragm was sutured. Blakely and Munson (1945) used the tire pump for their operative surgery. Milnes (1954) repaired diaphragmatic hernia on two dogs and a cat without using artificial respiration. Markowitz (1954) stated that the mouth blowing of human exhaled air into the canine trachea was feasible. However, he did not advocate it on esthetic grounds.

Subsequent to 1948 many different types of mechanical apparatus have been introduced for positive pressure ventilation. Of these the Robinson respiratory pump is reported to be ideal. It provides a large volume of compressed air at properly interrupted rhythmic intervals corresponding to the rate of normal breathing. The stroke of the pump is adjusted to provide

the volume of air necessary for large and small dogs. The power unit is a half horse power electric motor.

The handy resuscitator automatically administers artificial respiration. It operates on a principle of fixed positive and negative pressures of 13 mm. and 9 mm. of mercury respectively. The resuscitator supplies pure oxygen from a cylinder and exerts high and low intrapulmonary pressures in alternating sequences through an endotracheal tube with an inflatable cuff. The E. and J. Resuscitator-Inhalator-Aspirator which operates on the same principal as the Handy Resuscitator was available for this study.

In 1950, the Knight-Wood Apparatus was introduced. It consisted of a mechanically operated piston type valve which controlled the frequency of a variable volume of air delivered through a close fitting endotracheal tube. The open valve position allowed for inspiration and the closed valve position allowed for expiration by recoil. The valve mechanism was operated electrically and the frequency could be adjusted from 3 to 80 per minute.

SURGICAL ANATOMY

The thorax may be divided into the external covering, the bony cage, and the vital structures. The external covering is composed of the skin, the cutaneous trunci muscle, the fascia and the muscles. The muscles involved depend upon the site of the incision and its length. The muscles involved in the lateral approach include the trapezius, which arises from the median raphe of the neck and supra-spinous ligament from the level of the third or sixth cervical vertebrae to the level of the ninth or tenth thoracic vertebra and inserting on the spine of the scapula; the latissimus dorsi which originates from the spinuous processes of the lumbar, the last seven or eight thoracic vertebrae and the last two ribs and attaches to the

teres tuberosity of the humerus and the medial fascia of the arm; the serratus ventralis which arises from the serrated medial face of the scapula and inserts on the transverse processes of the last five cervical vertebrae and first seven or eight ribs slightly ventral to the middle; the deep pectoral which originates from the ventral part of the sternum, the fibrous raphe of its fellow muscle and the deep abdominal fascia and inserts on the greater and lesser tubercles of the humerus, the crest of the greater tubercle and the abdominal and adjacent caudal part to the medial brachial fascie. The muscles of the thoracic wall include the scalenus, the mid portion of which arises from the last two cervical transverse processes and is inserted on the fifth to ninth ribs. However, most of it may be covered by the external abdominal oblique muscle. The external intercostal muscles do not occupy the whole length of each intercostal space. They extend dorsally to blend with the levatores costarum. The internal intercostal runs ventro-craniad and almost at right angles to the external intercostal. The ventral surface of the thorax is covered by the abdominal muscles or their tendinous attachments. The abdominal muscles are made up of the two oblique muscles, the transverse and the rectus muscle.

The bony cage is composed of the vertebra, the ribs and the sternum. There are thirteen pairs of ribs and each has a bony and cartilaginous part. The cartilaginous portion, comprised of hyaline cartilage, is termed the costal cartilage. The four caudal pairs of ribs do not reach the sternum and are known as asternal ribs. The costal cartilages of the tenth, eleventh and twelfth on each side unite and form the costal arch. The thirteenth pair has no distal attachment and is termed the floating rib. The sternum is composed of eight segments called the sternebrae.

The vital structures are covered by the pleura, a serous membrane. This is composed of the visceral or pulmonary pleura which is very intimately attached to the lungs and the parietal pleura. These are two asymmetrical sacs which in most places attach to the thoracic wall by endothoracic fascia. The parietal pleura of each sac is divided into the costal, diaphragmatic, mediastinal and cervical parts. The costal portion covers the inner surface of the ribs and intercostal muscles. Near the diaphragm a capillary space, the phrenicostal sinus, is formed from the pleural reflection. The mediastinal pleura forms the sides of the partition between the two pleural cavities on the median plane. The acute angle of reflection of the mediastinum on the ribs is termed the costo-mediastinal sinus.

The left lung has three lobes while the right has four (Plate I, Fig. A and B). The cardiac notch is on the right lung and extends 4 to 6 cm. above the mid-ventral line. This notch exposes the right ventricle of the heart (Plate I, Fig. A). The long axis of the right ventricle is parallel to the fifth costal cartilage of the right side. The apical lobe of the left lung is bluntly pointed and lies over the manubrium sterni as in Plate I, Fig. B.

The heart is enclosed by a fibroserous sac, the pericardium, which is connected to the sternum by the mediastinal pleura and to the diaphragm by the pericardio-phrenic ligament. During diastole the base of the heart faces the thoracic inlet and is opposite the ventral part of the third rib. The apex is on the left side at the sixth interchondral space or seventh costal cartilage. The entrance of the pulmonary artery is near the fourth rib and the aorta at the fifth rib. The aorta runs forward and then turns backwards forming an arch. It leaves the thorax through the hiatus aorticus.

EXPLANATION OF PLATE I

Fig. A and B show the thoracic viscera from the right side and left side, superficial aspects and are taken from, "Guide to the Dissection of the Dog", by Miller.

PLATE I

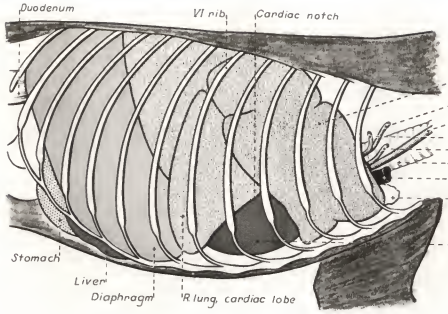

Fig. A Thoracic viscera from right side, superficial aspect.

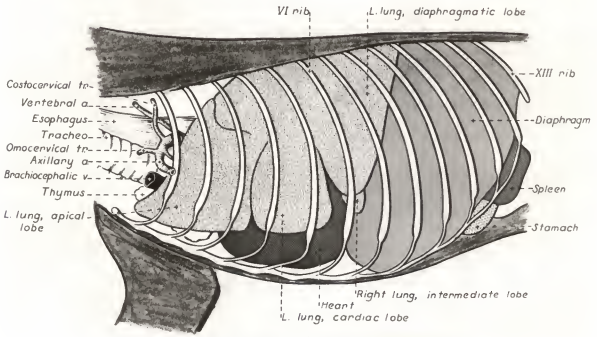

Fig. B Thoracic viscera from left side, superficial aspect.

The trachea lies in the mediastinal space and bifurcates opposite the fifth rib.

The esophagus is wide and dilatable except at its origin. At the thoracic inlet it lies to the left of the trachea. The thoracic part continues in this position and ventral to the left longus colli muscle until the trachea reaches the base of the heart. Here it inclines medially with the aortic arch to the left and passes above the tracheal bifurcation. Continuing posteriorly between the lungs, it usually inclines slightly to the left, and passes through the hiatus esophagus to join the stomach just to the left of the median plane and ventral to the eleventh or twelfth thoracic vertebra.

The crura or lumbar portion of the diaphragm is attached to the third or fourth lumbar vertebra. The costal portion of the diaphragm arises from the medial surfaces of the eighth to thirteenth ribs or their cartilages. The sternal portion of the diaphragm originates from the sternum at the xiphoid cartilage. The three openings in the diaphragm are the hiatus aorticus, the hiatus esophagus on the right crus, which also transmits the vagal nerve trunks and esophageal vessels, and the foramen vena cava through which the post vena cava emerges from the abdominal cavity. This foramen is located at the junction of the tendinous and muscular part of the diaphragm on the right. It is slightly above the dorso-ventral middle of the muscle as depicted in Plate II, Fig. A and B.

EXPLANATION OF PLATE II

Fig. A and B show the thoracic viscera from the right and left side, deep aspect.

PLATE II

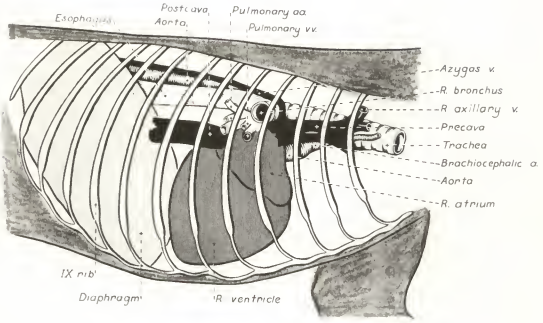

Fig. A Thoracic viscera from right side, deep aspect.

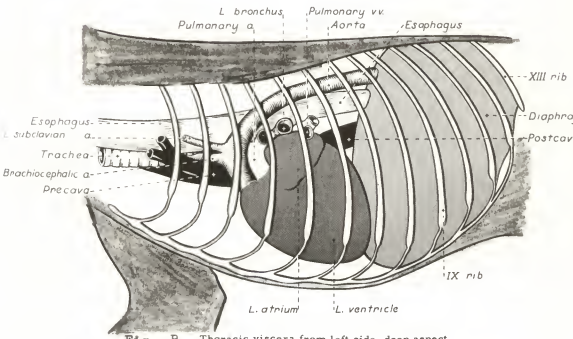

Fig. B Thoracic viscera from left side, deep aspect.

MATERIALS AND METHODS

Seven cadavers were dissected for the purpose of becoming familiar with the technique of thoracotomy. Two cadavers were utilized for the intercostal and rib resection approaches, two for the anterior sternotomy and two for the posterior sternotomy. The remaining cadaver was dissected to develop a cervical approach for thoracotomy.

Eleven dogs and three cats were utilized in the several experiments. They were of varied breeding and were acquired from the city pound for the purpose of experimental studies.

The instruments utilized were those usually found in a major surgery pack. The saw and the drill used in this study were a bonesaw, which was later replaced by a Tiny Tim hacksaw and a drill, purchased at a hardware store with a 1/16 inch awl. The instruments and accessories were sterilized in an autoclave for 30 minutes at 250°F. and 15 pounds pressure. The saw, rib retractor, awl, tubing, and the needle for drawing air from the pleural cavity made up a separate pack.

Following the induction of anesthesia with pentobarbital sodium, the operative site was carefully prepared by clipping, scrubbing with soap and water, cleansing with ether and applying an alcoholic roccal pack.

A Magill's intra-tracheal tube equipped with an inflatable cuff, and of the proper size, was introduced into the trachea. The intubation technique consisted of grasping the epiglottis with a pair of tissue forceps, depressing and pulling the tongue forward. The tracheal tube was inserted through the glottis and into the trachea for a distance of two inches. The cuff was then inflated using approximately 5 cc. of air which was injected through the accessary tube. The amount of air depended on the size of the tracheal tube

and internal diameter of the trachea. After inflation the free end of the accessory tube was clamped with a pair of hemostats to prevent deflation. Positive pressure ventilation of the lungs on dogs and cats 1, 2, and 3 was maintained throughout the surgery with the aid of the E. and J. Resuscitator.

On dogs and cats 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14 an ordinary rubber tubing was attached to the exposed end of the Magill intratracheal tube. When the pleura was opened and the lungs began to collapse, the operator or his assistant maintained the respiration by periodically blowing into the rubber tubing. The rate of blowing was 15 per minute for a dog weighing 20 to 40 pounds body weight. The frequency of blowing was lower in small dogs than in the larger ones. The lungs were routinely inflated to one half capacity. This was easily gauged when the thorax was opened and the lungs visible. Observation of the glossal and labial mucous membranes for cyanosis aided in determining the frequency of inflation. A bright pink mucous membrane indicated adequate ventilation. Like a metronome moving rythmically, the assistant should count one, two, three, and four. At the count of four the lungs are inflated by blowing into the tube. At the count of one, two and three atmospheric pressure compresses the inflated lungs causing them to collapse and resulted in exhalation. Twenty five percent of the dogs continued voluntary breathing even though the lungs were partially collapsed.

Before final closure of the thoracotomy wound, a sterilized rubber tube was inserted into the pleural cavity. After the suturing of the pleura and muscles, the lungs were fully inflated by mouth breathing. At this juncture, the operator or the assistant aspirated the air from the pleural cavity through the tubing. The tubing was then removed. The dog was allowed to exhale air and voluntary respirations commenced. The aspiration of the air

was accomplished by applying suction on the tube with a 50 cc. syringe.

Aftercare consisted of daily exercise plus morning and evening feeding. Bandaging and antibiotics were not used in any of the experimental animals.

Experimental Dog No. 1 was a Terrier weighing 35 pounds and in fair health. Anesthesia was produced by the intravenous injection of 7 cc. sodium pentobarbital. Following preoperative preparation of the site, the animal was placed on the operation table and endotracheal intubation performed. The dog was then positioned in lateral recumbency. Draping of the site was then accomplished and the free end of the endotracheal tube was connected to the resuscitator. The resuscitator was tested for its efficiency and the control valve closed.

Exercising aseptic precautions an incision 15 cms. long was made through the skin, the cutaneous trunci muscle, and the subcutaneous fascia over the sixth rib. The trapezius and the latissimus dorsi muscles were incised in the line of the skin incision. The serratus ventralis muscle was separated in the line of its fibers. The longissimus dorsi muscle was separated from the posterior margin of the rib near the vertebral end. At the ventral end of the rib the fibers of the internal abdominal oblique and external abdominal oblique muscles were separated. The rib was then clearly visible. Hemorrhage, as and when it occurred, was controlled by ligation with No. 8 cotton ligature. An incision was then made over the center of the exposed rib. The periosteum of the rib was then carefully dissected free and with a rib stripper, the periosteum was separated from the rib. The rib was cut at the superior and inferior ends with a bone cutter and removed. The pleura was next punctured at expiration to partially collapse the lung and the incision extended for a distance of 9 cms. The resuscitator was turned on by the

assistant. The retractors were then introduced and the rib retracted for visual inspection and exploration.

An area three inches wide was visible allowing a clear view of the cardiac and diaphragmatic lobes of the lung. When these structures were retracted the intermediate lobe of the lung was seen. The posterior part of the esophagus, the posterior vena cava, the thoracic aorta and the apex of the heart were easily seen. The diaphragm, though visible, was not easily reached. The closure of the wound was accomplished by passing two stainless steel retention sutures through the fifth intercostal space and out through the seventh intercostal space. One end of the rubber tubing for producing negative pressure in the thorax was placed in the pleural cavity and the other end was placed outside close to the end of the wound. The pleura and periosteal incisions were closed with No. 8 cotton sutures. The fibers of the external abdominal oblique and serratus ventralis muscles were approximated and the latissimus dorsi, trapezius, longissimus dorsi muscles were sutured with cotton. Lastly the skin was sutured with interrupted wire sutures. Before the last suture was tied, air from the pleural cavity was aspirated to produce negative pressure in the pleural cavity. The rubber tubing was then removed and the suture tied.

The dog made an uneventful recovery and was destroyed one week post-operatively.

Experimental Dog No. 2 was a Mongrel weighing 18 pounds and whose health was satisfactory. Anesthesia was by the intravenous injection of 4 cc. of sodium pentobarbital. After careful preparation of the site, the animal was placed on the table and the endotracheal tube was inserted. The patient was then positioned in lateral recumbency. Draping of the operative site was

was done, the resuscitator tested and its control valve closed.

Under careful asepsis, an incision 10 cm. long was made through the skin, cutaneous trunci and fascia in the fourth intercostal space. The underlying muscles which included the trapezius, latissimus dorsi, serratus ventralis and longissimus dorsi, oblique muscles of the abdomen and deep pectorals were incised or separated. When the intercostal space was reached, the pleura was punctured during expiration and the resuscitator placed in operation. The intercostals and levatores costarum were incised. The retractors were applied revealing the cardiac and diaphragmatic portion of the lung, the anterior vena cava, aorta, trachea, middle portion of the thoracic esophagus, left side of the heart, the thymus and mediastinal lymph glands (Plate III).

Wire sutures were passed anterior to the fourth rib and brought out posterior to the fifth rib and tied. The rubber tubing for producing negative pressure was placed in position at one end of the wound and the intercostal muscles with the pleura were sutured by interrupted sutures of size 8 cotton. The muscles were then sutured with the same material, as was the skin. Before tying the last suture, the air from the pleural cavity was withdrawn through the rubber tubing and the tubing was withdrawn.

This animal recovered and was destroyed seven days postoperatively.

Experimental animal No. 3 was a cat weighing 12 pounds and in good health. Anesthesia consisted of the intrathoracic injection of 2-1/2 cc. of sodium pentobarbital. After careful preparation of the site, the animal was placed on the operating table and endotracheal intubation was performed. The patient was then positioned in the lateral position. After draping the operative site, the resuscitator was tested and its control valve closed.

EXPLANATION OF PLATE III

Shows lateral thoracotomy through an intercostal incision and the important structures visable.

PLATE III

Lateral Thoracotomy - intercostal incision

An incision 8 cms. long was made through the skin, cutaneous trunci muscle and the fascia at the sixth intercostal space. The underlying muscles were incised or separated. When the intercostal space was reached, the pleura was punctured through the intercostal muscles during expiration and the resuscitator valve was opened. The incision was extended through the intercostal and the levatores costarum muscles. Retraction of the wound revealed the cardiac and diaphragmatic portions of the lung, anterior vena cava, aorta and trachea.

The closure of the wound was accomplished in the manner described in the previous cases. As the last suture was being placed in the skin, the oxygen supply failed and the cat died.

Experimental animal No. 4 was a Spaniel weighing 16 pounds. Anesthesia was obtained by the injection of 4 cc. of pentobarbital sodium intravenously. After careful preparation of the site, the dog was positioned in dorso-recumbency. The rear legs were stretched posteriorly and fastened to the operating table. The forelegs were abducted and tied to the sides of the table. An incision was made extending from 3 cms. above the manubrium sterni to the posterior end of the middle third of the sternum. The cutaneous trunci muscles and the fascia were incised. The incision was extended through the tendinous union of the pectoral muscles at the midline. In the cervical area, the sternocephalicus muscle was divided medially. The sternum was divided in the midline. The instrument utilized for this purpose was a Tiny Tim hack saw. Respiration was maintained by mouth breathing into the rubber tube connected to the intratracheal tube. The divided sternum was retracted for visual inspection and exploration.

The heart and both lungs were clearly visible. The diaphragmatic lobes of both lungs and the intermediate lobe of the right lung were partly visible. The anterior vena cava and pulmonary artery were clearly visible and also the anterior half of the thoracic esophagus and the trachea.

The sternum was united with interrupted silk sutures, size 8, placed around the sternal fragments at the interchondral spaces. Three such sutures were placed. Prior to the closure of the sternum, the rubber tubing was introduced at the anterior end near the manubrium sterni. The cutaneous trunci muscle and the skin were sutured separately using interrupted sutures of cotton, size 8. Before tying the last suture near the anterior end, the rubber tubing was removed after its purpose was served.

Recovery was uneventful and on the sixth day while being exercised the dog started chasing a rabbit. X-ray on the tenth day demonstrated a normal healing process with no abnormalities.

Experimental animal No. 5 was a cat weighing 15 pounds. Anesthesia was induced by injecting 3 cc. sodium pentobarbital intrathoracically. Following the initial incision, an attempt was made to divide the sternum. Difficulty was encountered in dividing the sternum and the actual incision was made through the chondral articulation on the right side. When the pleura was punctured positive pressure ventilation was maintained by mouth to tube breathing.

The structures visible on opening the mediastinal pleura were the heart, anterior lobes of the lungs, the anterior vena cava, the pulmonary artery, the anterior half of the thoracic esophagus and the trachea (Plate IV).

The wound was closed by suturing the intercostal muscles to the sternebra and then suturing the pectoral muscles of the right side to those

EXPLANATION OF PLATE IV

Shows ventral thoracotomy by means of anterior sternotomy and the important structures visible.

PLATE IV

Ventral Thoracotomy - Anterior Sternotomy

of the opposite side. Lastly the cutaneous trunci and skin were sutured.

Death, due to leakage of the cuff on the endotracheal tube occurred during the suturing process.

Experimental animal No. 6 was a cross-bred Mexican dog weighing 12 pounds. Ovaro-hysterectomy had been performed one week previously. Three cc. of sodium pentobarbital injected intravenously produced surgical anesthesia. The thoracotomy technique adopted was the same as that used in experimental animal No. 4.

This dog made an uneventful recovery. On the fifth day it fell from a height of four feet which had no apparent effect on the healing process. Radiographs on the ninth and again on the eighteenth day revealed normal healing process.

Posterior sternotomy was performed on experimental animals, Nos. 7, 8, and 9. Experimental animal No. 7 was a Mongrel dog weighing 32 pounds which was in a poor state of health. Anesthesia was produced by injecting 7 cc. of sodium pentobarbital intravenously.

Experimental animal No. 8 was a dog weighing 22 pounds in fair condition. Anesthesia was induced by injecting 5 cc. of sodium pentobarbital intravenously.

Experimental animal No. 9 was a Mongrel puppy weighing 20 pounds. Anesthesia was by the intravenous injection of 4 cc. of pentobarbital.

Following endotracheal intubation, the dogs were positioned in a dorso-recumbent position with the hind legs stretched and tied posteriorly, and the forelegs abducted and extended anteriorly. The initial incision was made from the anterior third of the sternum and extended posteriorly to the umbilicus along the linea alba. The abdominal incision was completed through the peritoneum. The incision into the thoracic cavity was accomplished by

sawing through the sternum on a midline extending forward for two thirds of its length. Positive pressure ventilation was maintained by mouth to tube breathing. Following division of the sternum, the diaphragm was incised approximately one half inch and the retractors inserted. The diaphragm, the posterior half of the thoracic esophagus, the posterior aorta, the posterior vena cava, the cardiac and diaphragmatic lobes of the lungs, the intermediate lobe of the right lung and the apex of the heart were clearly visible.

The closure of the sternal wound was performed by drilling corresponding holes through either side of the sternum. Stainless steel wire was passed through corresponding holes on either side of the sternum and tied on the ventral surface. The tubing for inducing negative pressure was introduced close to the xiphoid cartilage through the abdominal and diaphragmatic wounds. The peritoneum was then sutured with size 8 cotton. The abdominal muscles with their fascia and the skin were sutured using the same suture material. Before the tying of the last suture the rubber tubing was withdrawn after inducing negative pressure.

Experimental dog No. 7 died 24 hours postoperatively. Death was attributed to debility and shock.

Experimental dogs, Nos. 8 and 9, made uneventful recovery and were destroyed on the eighth day postoperatively.

Experimental animal No. 10 was a cat weighing 10 pounds. Anesthesia was obtained by the intrathoracic injection of 2-1/2 cc. of sodium pentobarbital.

Following the preoperative procedures the incision was made in the sixth intercostal space, extending from the upper third of the thorax to

the sternum. The trapezius, latissimus dorsi, serratus ventralis, external abdominal oblique, and internal abdominal oblique muscles were incised and the pleura divided. Artificial respiration was maintained by mouth to tube breathing. A similar incision was made on the other side and the sternum divided transversely. The internal thoracic arteries were ligated at two points and severed between the ligation. The transverse thoracic muscle dorsal to the sternum was then divided.

The major internal structures were well exposed and afforded ample manipulation (Plate V).

The closure of the wound was accomplished by passing a threaded suturing needle into the seventh interchondral space and bringing it out through the fifth interchondral space on either side of the sternum. When tied these retention sutures approximated the sternal fragments. Similar sutures were placed at one inch intervals along the wound. The intercostals and levatores costarum muscles were sutured with size 8 cotton thread. After suturing the muscles on both sides, the skin was closed with interrupted cotton sutures. The rubber tubing for producing negative pressure had been placed in the pleural cavity close to the dorsal end of the intercostal incision. This was removed when the last skin suture was tied.

Death due to shock occurred at the conclusion of surgery.

Experimental animals, Nos. 11, 12 and 13, were subjected to transthoracic thoracotomy.

Experimental animal No. 11 was a Mongrel dog weighing 22 pounds. Anesthesia was induced by the intravenous injection of 4 cc. of sodium pentobarbital.

EXPLANATION OF PLATE V

Shows transthoracic thoracotomy and the important structures visible.

PLATE V

Transthoracic Thoracotomy

Experimental animal No. 12 was a Cocker Spaniel weighing 20 pounds. Anesthesia was induced by intravenous injection of 4 cc. of sodium pentobarbital.

Experimental animal No. 13 was a Dachshund weighing 30 pounds. Anesthesia was accomplished by injecting 8 cc. of sodium pentobarbital intravenously.

The dogs were secured in dorso-recumbency. An incision was made from the sternum upward along the interchondral and intercostal spaces. Artificial respiration was mouth to tube breathing. A similar incision was made on the opposite side of the chest. The sternum was divided transversely, the internal thoracic vessels ligated and the transverse thoracic muscle incised. The major internal structures were exposed and there was ample space for bimanual manipulation.

The closure of the wound was accomplished by approximating the sternum with stainless steel sutures placed through holes drilled on either side ventrodorsally. The ribs were approximated and the intercostal and levatores costarum muscles sutured. Suturing of the muscles of the thorax and the skin completed the closure.

The tubing used to produce negative pressure in the thoracic cavity was withdrawn prior to the final stitch.

Experimental dog No. 11 died on the fourth postoperative day and death was due to preoperative debility. Dogs, No. 12 and 13, made uneventful recoveries and were destroyed on the eighth day following surgery.

Experimental dog No. 14 was a Pointer weighing 68 pounds. Anesthesia was induced by the intravenous injection of 12 cc. sodium pentobarbital. The dog was placed in the dorso-recumbency. The forelimbs were abducted,

extended posteriorly and tied to the table side. The hind limbs were not secured.

A semicircular incision was made anterior to the thoracic inlet. It extended outward and upward on either side for 6 cms. The incision was close to the anterior ventral border of the first rib of one side and continued to the corresponding rib of the other side of the chest enclosing the manubrium sterni in its center. The cutaneous cervicalis muscle was incised and the fascia dissected. The sternocephalicus muscle was divided at its insertion. The sternothyrohyoideus muscle of each side was retracted and the thoracic inlet exposed. Positive pressure ventilation was maintained by mouth to tube breathing.

The structures clearly visible were the anterior thoracic trachea and the anterior thoracic esophagus. The anterior mediastinal lymph nodes could be manipulated but visibility was poor.

Before suturing a rubber tubing was placed in the pleural cavity between the manubrium and first rib. The pleura was sutured with fine silk. The sternocephalicus muscles, cutaneous cervicalis and skin were closed with interrupted cotton sutures No. 8. The rubber tubing was removed prior to tying the last suture.

Recovery was uneventful and the dog was destroyed on the eighth day postoperatively.

DISCUSSION

Positive pressure ventilation of the lungs is an important factor in thoracotomy and consequently it must be considered in any study conducted which involves thoracic surgery.

In experimental animals, dogs No. 1 and 2, and cat No. 3, the E. and J. resuscitator was utilized. While this apparatus was highly adequate the original cost may prohibit its use in small clinics. Consequently on experimental animals, dogs No. 4, 6, 7, 8, 9, 11, 12, 13, and 14 and cats No. 5 and 10, a simpler technique was devised. The positive pressure was maintained either by the surgeon or his assistant and consisted of the mouth to tube breathing of human exhaled air. The technique was successful in nine dogs. The experience gained through these experiments would indicate that this method might well be substituted for the expensive apparatus now considered essential for thoracic surgery. The principal drawback is one of aesthetic nature. The exchange of human exhaled air for the air in the canine lung provides adequate ventilation as indicated by the color of the mucous membrane throughout surgery. The probability of transmitting infection by this technique is very slight. The inclusion of a filter in the tube leading to the tracheal tube might well be accomplished and would reduce the possibility of transmitting infection. The force of breathing however, will have to be increased should the filter be introduced. While the cats, experimental animals No. 5 and 10 succumbed, the cause of death could be attributed to failure of the tracheal cuff in cat No. 5 and to surgical shock in cat No. 10.

If this type of positive lung respiration is to be successful, the assistant or the operator should have good lung capacity and sufficient endurance, since it was a tiring procedure. However, as an emergency measure it could safely be used.

The lateral approach was utilized for the thoracotomy incision in two dogs and one cat. This method has been the accepted approach ever since its

description by Secord in 1942. It may involve either the intercostal incision as in experimental animal 2 and 3, a dog and a cat or the rib resection, as in experimental dog No. 1.

Based on these studies the advantages of this method are the relative ease of making the incision, the definite landmarks for the incision and the accessibility of structures for closing the incision.

The disadvantages of this method are that the visibility and accessibility of the internal structures are limited to the side on which the incision had been made. It cannot be performed anterior to the fourth rib, consequently the anterior mediastinal structures are not accessable. The selection of the site must be carefully considered as the lateral incision cannot be extended either dorsally or ventrally to enhance the field of exposure. From the standpoint of exploratory thoracotomy this approach has definite limitations since only a restricted area was exposed by the single incision and that area was limited to one side. Other minor disadvantages noticed were that the method was time consuming and complete hemostasis was somewhat difficult.

Anterior sternotomy was performed on two dogs and a cat. This was a new approach in canine surgery. It had been performed in man but was not considered the approach of choice. It was reported to be a formidable one in man because of the danger of puncturing a lung during the sternal division. This did not appear to be a factor in this study probably because of the anatomical differences in the shape of the chest of man and animals.

The positioning of the patient was extremely important. Positioning the animal in dorso-recumbency with the rear limbs extended backward and outwards and the forelimbs abducted and tied to the respective sides of the

table prevented side to side rotation of the patients body and made the sawing procedure much easier. Selection of a proper saw was essential in the technique. The Satterlee bone saw proved to be extremely unsatisfactory because of the blade thickness and the position of the handle. The thick blade tended to destroy an excessive amount of bone and the handle prevented proper angulation for the sawing procedures. A Tiny Tim hack saw obtainable at hardware stores was found to be useful and efficient. The guarded ends permitted partial introduction into the chest for the further extension of the sternotomy. The handle was located in such a position that it did not hamper the sawing action.

Anterior sternotomy was unsuccessful on experimental animal No. 5, a cat. Instead of sawing the sternum, the costo-chondral articulation of the ribs were cut. The relatively narrow sternum associated with the greater flexibility of the thoracic cage were the major factors preventing successful sternotomy.

The chief advantages of anterior sternotomy are the degree of exposure obtained of the anterior mediastinal structures, the accessibility of all structures in the anterior half of the thorax and the ease of bimanual exploration. The anterior sternotomy approach is more versatile in that the field of exploration can be enlarged at will and is not limited as in the case in the lateral approach. An additional advantage may be the reduced number of muscles involved in the incision.

Possible disadvantages of this approach would be the longer period required for complete healing to occur and the accessibility of structures immediately dorsal to the heart and aorta. The apparent lack of pain or inconvenience of motion should nullify any objection because of the healing time.

Posterior sternotomy was performed on experimental animals Nos. 7, 8, and 9. Sawing from the posterior to anterior was found to be more satisfactory and safer than the reverse. While in anterior sternotomy, the cut edges of the sternum were tied by sutures passing through the interchondral space, in posterior sternotomy the divided halves of the sternum were approximated by sutures passed through holes drilled in the sternum ventrodorsally. Either of the two methods was found to be satisfactory for sternal apposition.

The advantages were the easy exposure of the posterior mediastinal organs. These were clearly visible, easily accessible and there was ample opportunity for bimanual exploration. The trauma to tissue was limited and contributed to the quick recovery of the patient. Both halves of the chest cavity were visible and the greatest advantage was that the primary incision could be extended either cranially or caudally. If necessitated both a thoracic and an abdominal operation could be performed with only one incision.

Probable disadvantages would be the opening up of the two cavities, the thorax and the abdomen, the incision of the diaphragm and the cutting of cartilage or bone, which usually takes a longer time for repair than structures such as the muscle and skin.

Transthoracic thoracotomy was performed on experimental dogs, numbers 11, 12, and 13 and cat No. 10. Butler (1957) first described this technique. The "transthoracic" operation, described by Knight in 1951 and Menon in 1953 were essentially a lateral approach. In man transthoracic is sometimes used synonymously with the lateral approach. The canine thorax is barrel shaped and compressed laterally, while in man it is flattened antero-posteriorly, consequently the terminology of Butler for the sawing transversely through the sternum would be the appropriate designation for this approach.

Considerable difficulty was encountered in extending the incision from the intercostal space into the interchondral space. For this reason the incision was commenced at the sternum and extended upward along the interchondral and intercostal space in this method. The two incisions diverged backwards to the costochondral junction and thereafter forwards and dorsally and assumed the shape of a "W".

The advantages observed included excellent visibility, adequate space for bimanual exploration and surgical procedures.

The disadvantages were the overexposure of the tissues to atmospheric conditions and the surgical trauma occurring as the result of incising more than twice the number of or same structures involved in the lateral approach. Complete hemostasis was difficult to achieve as illustrated in experimental animal No. 10, a cat, which died of surgical shock. One of the dogs, experimental animal No. 11 also succumbed, but this death could be attributed to the general debility of the patient at the time of surgery. In addition, this technique was highly time consuming. These factors have probably deterred other surgeons from utilizing the technique described by Butler.

The cervical approach was adopted on experimental animal No. 14, a dog. The only reference found concerning the method were in texts on human surgery. For this technique the dog was positioned in dorso-recumbency with the forelimbs abducted and tied to the sides of the table. This aided the operative technique. The hind limbs were not secured.

The advantages were the simplicity of the technique, the relatively low traumatization of tissues and the bloodless dissection encountered.

This technique has many limitations. There was poor visibility and most structures in the anterior thorax were relatively inaccessible.

However, the esophagus and the trachea at the thoracic inlet were clearly visible. Consequently this technique could be used for removing foreign bodies lodged in the esophagus and trachea at the thoracic inlet.

CONCLUSION

These conclusions are based on the knowledge obtained by dissecting cadavers and surgery on 11 experimental dogs and three cats.

Thoracotomy may be performed for the surgical removal of the lung or its lobes, heartworms, mediastinal tumors, spirocercal nests, foreign bodies in the thoracic portion of the esophagus, cardioplasty for achalasia, reduction of diaphragmatic hernia and ligation of the thoracic duct.

1. Thoracotomy can be performed only with the aid of positive pressure ventilation of the lungs.

2. A simple technique of positive pressure ventilation of the lung consists of mouth blowing of human exhaled air into the lungs of the canine, through an intratracheal tube fitted with an inflated cuff.

3. In an emergency the careful insertion of moist cotton in the space around the tracheal tube in the pharynx could be substituted for a tracheal cuff.

4. The lateral approach, whether intercostal or involving rib resection are of little value for surgical procedures in the thoracic inlet and anterior mediastinal area.

5. The ventral approach, either anterior sternotomy or posterior sternotomy, are a very practical approach for canine thoracotomy. The tissue damage is negligible, the visibility good, artificial lighting easily possible and there is ample room for bimanual exploration plus ample scope

for the operator to extend or limit the incision.

6. The transthoracic approach can be performed at any intercostal space from the fifth to the ninth rib. Because of the extensive incision this approach must be classified as radical surgery.

7. The cervical approach has a very limited application in Veterinary Surgery. The principal indication would be the presence of either a tracheal or esophageal foreign body in this area.

8. Exploratory thoracotomy may be accomplished from several approaches and should become more extensively utilized as familiarity with the various techniques increases.

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A STUDY OF THE VARIOUS APPROACHES FOR THORACOTOMY IN CANINES

by

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Thoracotomy is the surgical opening of the thorax for visual inspection, surgical exploration and operative procedures on intrathoracic structures.

The principal indications for this operation are pneumonectomy, lobectomy, extirpation of tumors, cysts or lymph glands in the mediastinum, ventriculotomy, arteriotomy, patent ductus arteriosus, cardioplasty, persistent right aortic arch,thoracic esophagotomy, diaphragmatic hernia and ligation of the thoracic duct.

Despite the work done so far, there is still apathy towards this operative procedure. This is probably due to the initial cost of equipment required for positive pressure lung ventilation, the need of an assistant and the seemingly relatively low incidence of the conditions requiring thoracic surgery.

The standard method for thoracotomy has been the lateral approach since its introduction by Secord in 1942. However, the limitations of this approach are that the space afforded between the ribs was insufficient for bimanual exploration and visual inspection, poor artificial lighting and the lack of accessability of the structures in the anterior mediastinum and thoracic inlet.

This study was undertaken to explore the possible sites for thoracotomy with the hope of improving the accessability and visibility of internal structures, expedite bimanual exploration, illuminate the interior properly and to simplify the technique. While not directly linked with the primary purpose of the study, certain trials were made regarding the positive pressure ventilation of lungs to evaluate their effectiveness.

On three experimental animals the E. and J. resuscitator was utilized. On 11 experimental animals the maintenance of positive pressure was by the

mouth to tube breathing of human exhaled air. The mouth to tube breathing was commenced when the pleura was incised and ceased when the pleura had been artificially repaired and a vacuum created in the pleural cavity. The normal breathing of the animal resumed immediately after the artificial respiration was stopped.

The lateral approach was utilized on three experimental animals. On one a rib resection was performed. On two the intercostal method was used. Other approaches utilized in this study were the anterior sternotomy, posterior sternotomy, the transthoracic and the cervical. On three animals anterior sternotomy was performed by dividing the anterior one half of the sternum. On three animals posterior sternotomy was done. This was accomplished by division of the sternum from the middle of the sternum to the xiphoid cartilage. The incision extended posteriorly to include the abdominal wall. On four animals the transthoracic thoracotomy was performed. The operation consisted of opening both sides of the chest in a particular intercostal space and later sawing through the sternum in a transverse manner. On one dog the cervical method was used. This was performed by making a semicircular incision at the base of the neck enclosing the manubrium sterni.

The principal disadvantages of the lateral approach were the inaccessibility of the structures anterior to the fourth rib and the inability to extend the thoracotomy incision both dorsally and ventrally. In anterior sternotomy these disadvantages were overcome in so far as the structures in the anterior portion of the thoracic cavity were concerned. In posterior sternotomy the initial incision could be extended either way. The structures in the posterior thoracic cavity were well lighted and the

incision provided adequate space for bimanual work. In the transthoracic approach the main disadvantages were the over exposure of the tissues to atmospheric conditions, the extensive trauma and the time consuming technique for repair of the wound. The cervical approach provided poor visibility and relative inaccessibility to any of the internal structures excepting the trachea and the esophagus at the thoracic inlet.

In concluding it is suggested that the ventral approaches, namely anterior sternotomy and posterior sternotomy have great possibilities of replacing the lateral approach in thoracotomy. The transthoracic approach may be necessitated in rare instances.